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Stuckmann

[11] **4,334,800**

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[54] **TUNNEL DRIVE SHIELD**

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[73] Assignee: **Gewerkschaft Eisenhutte Westfalia,** Fed. Rep. of Germany

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[3] **E21D 19/00**

[52] **U.S. Cl.** **405/145;** 405/141; 405/288

[58] **Field of Search** 405/139–146, 405/288, 290, 291, 298, 299, 303; 299/31, 33; 175/219

[56] **References Cited**

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Primary Examiner—Dennis L. Taylor
Attorney, Agent, or Firm—Thompson, Birch, Gauthier & Samuels

[57] **ABSTRACT**

A tunnel drive shield has an arcuate support frame constituted by a pair of foot segments, a pair of wall segments supported by the foot segments and a ridge segment connecting the tops of the wall segments. The foot segments engage the tunnel floor, and the wall segments are braceable outwardly towards the tunnel walls. Each foot segment is provided with a pair of longitudinal floor skids displaceably mounted on the base thereof. Each foot segment is also provided with a pair of longitudinally-spaced, vertically-movable support feet, which are movable into contact with the tunnel floor to relieve, at least partially, the load on the floor skids. The support feet are used to support the shield while the floor skids are removed. The rest of the shield can then be dismantled within the confines of the tunnel.

26 Claims, 7 Drawing Figures

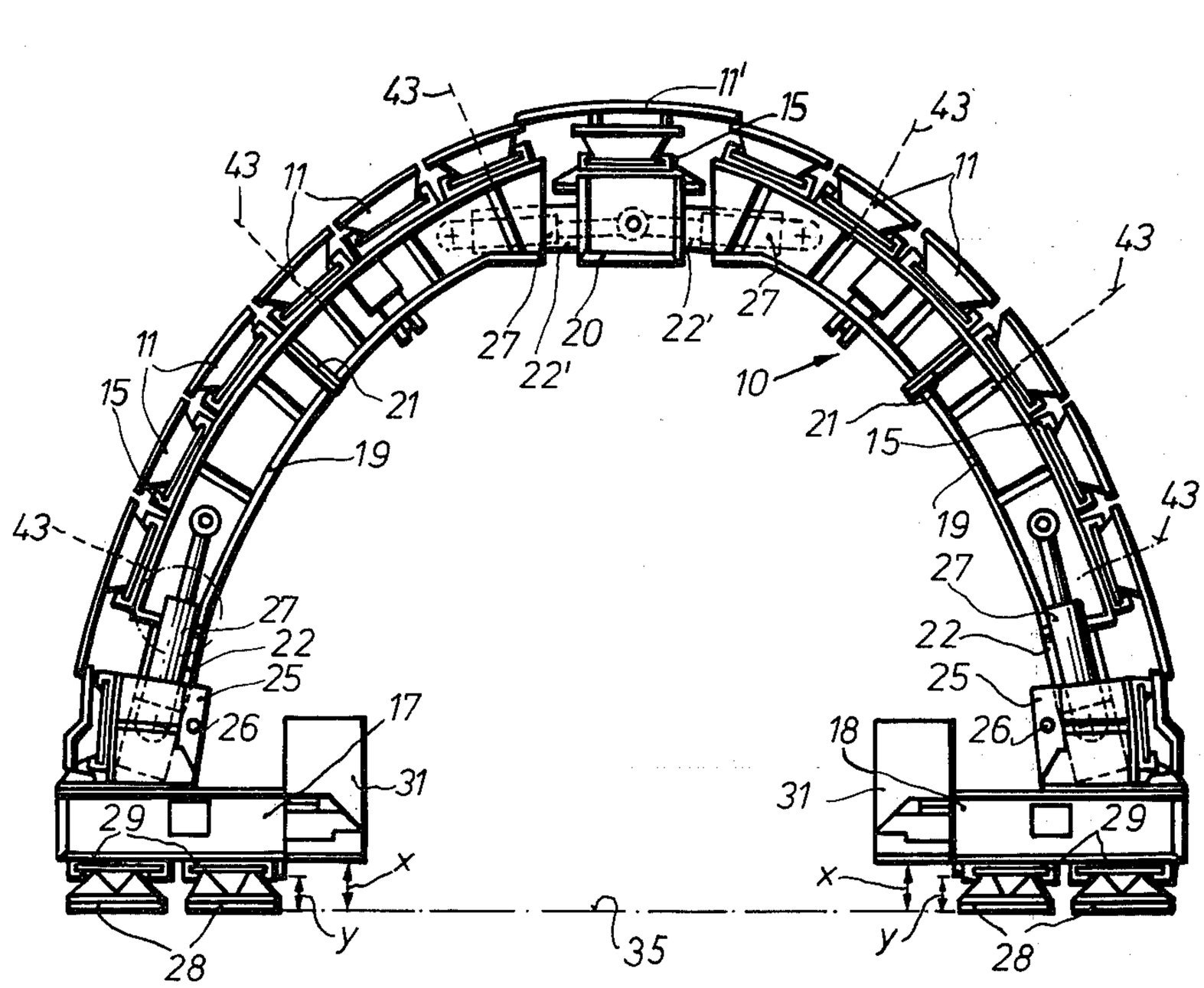
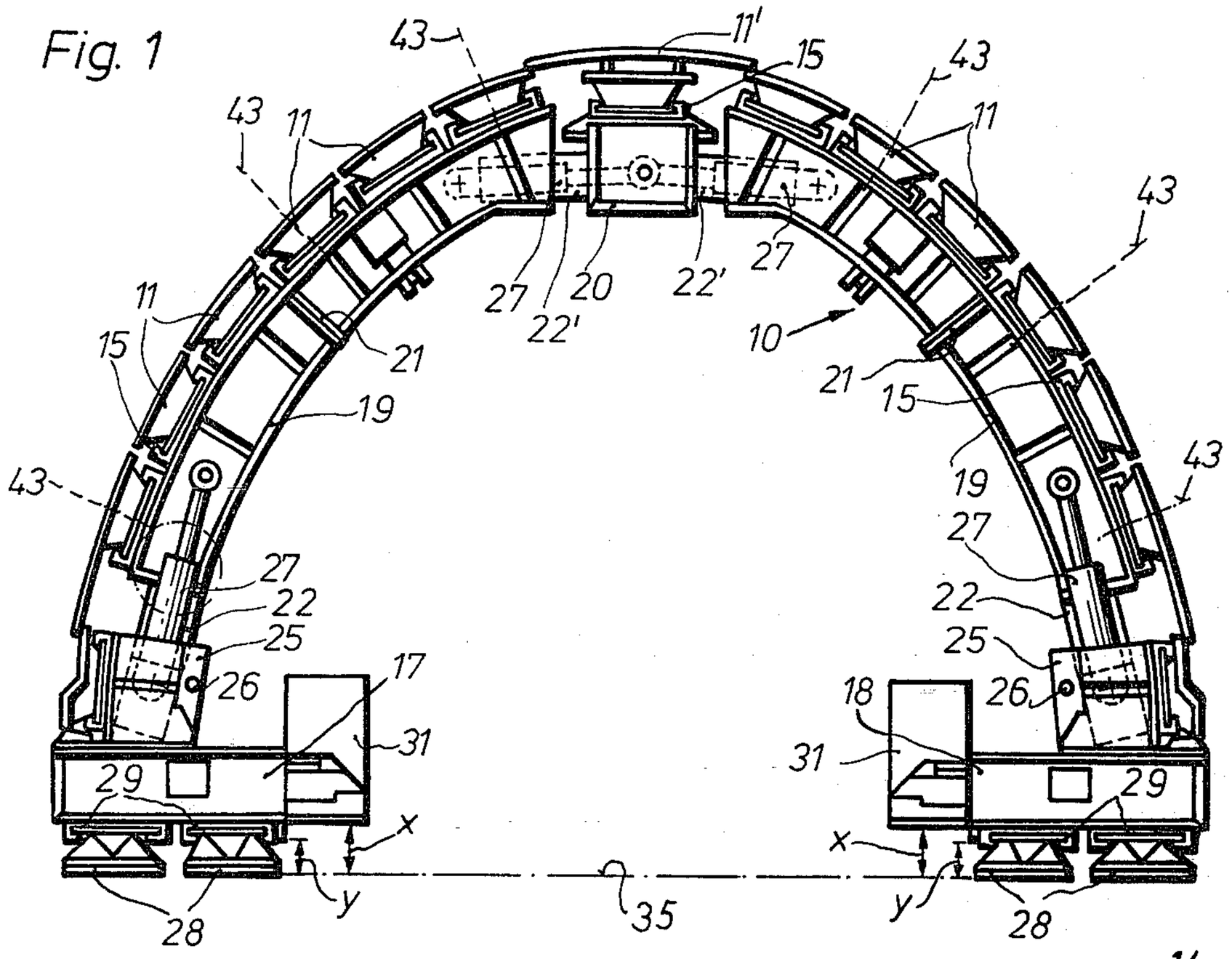


Fig. 1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x
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28

Fig.2

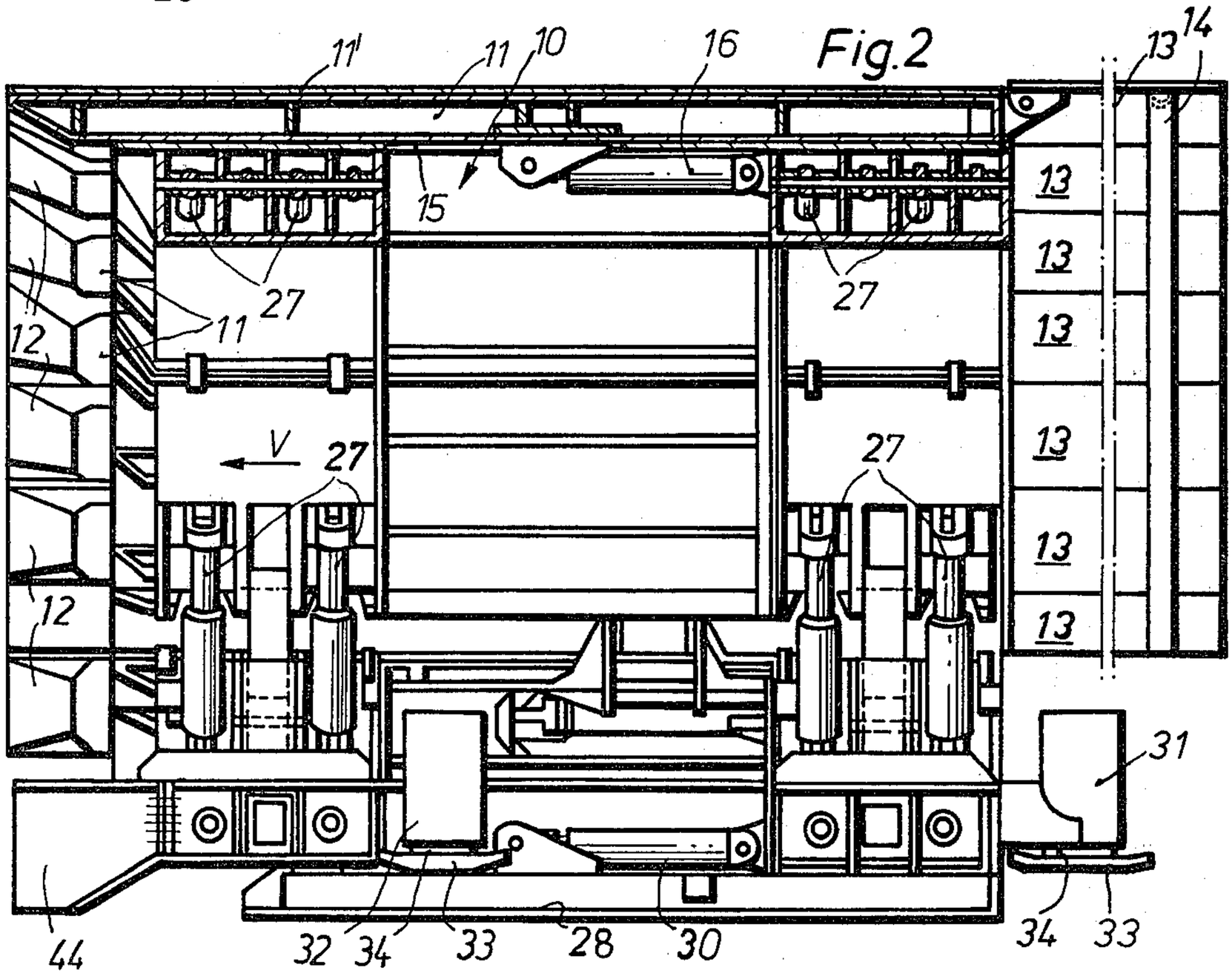
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Fig. 3

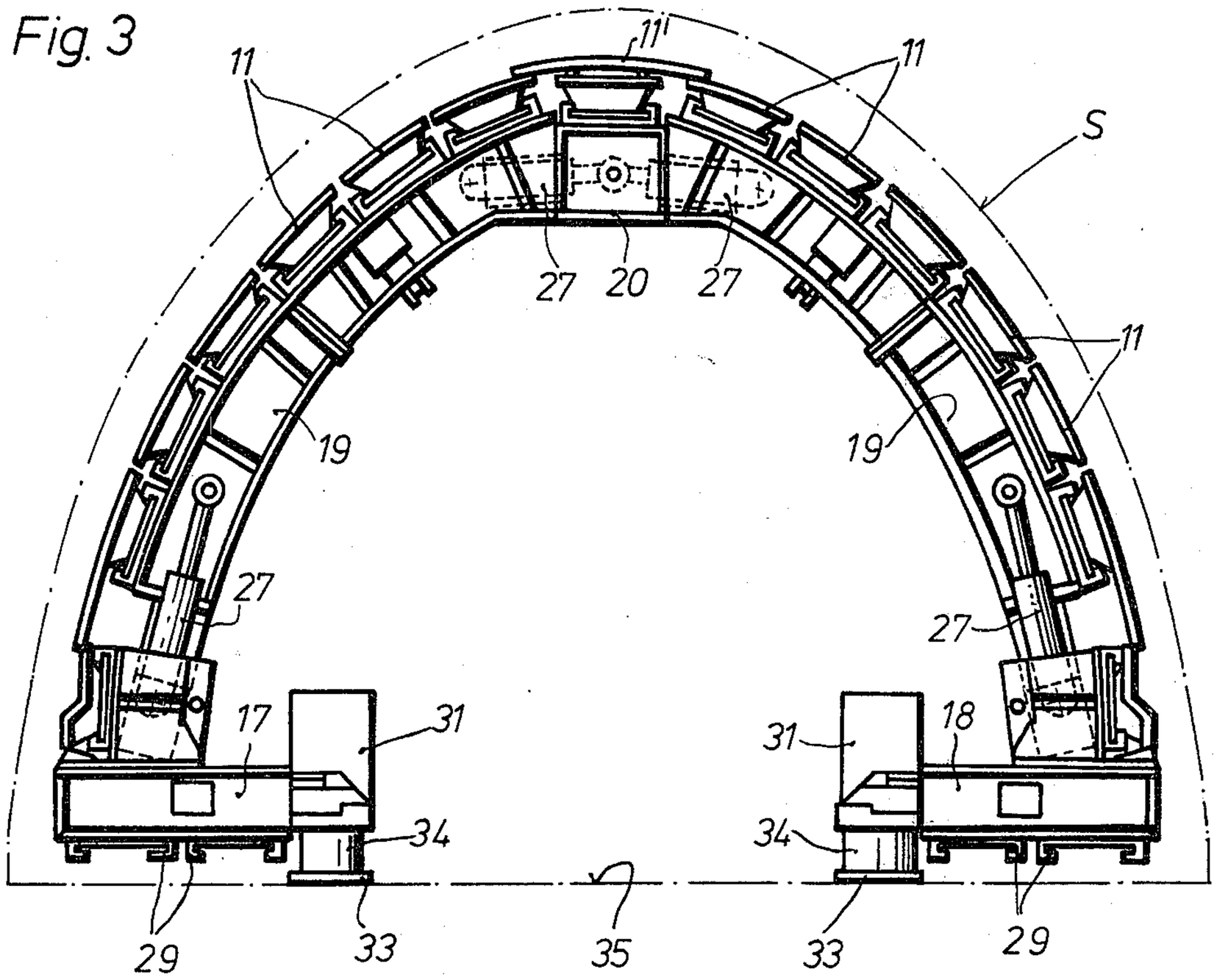
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Fig. 4

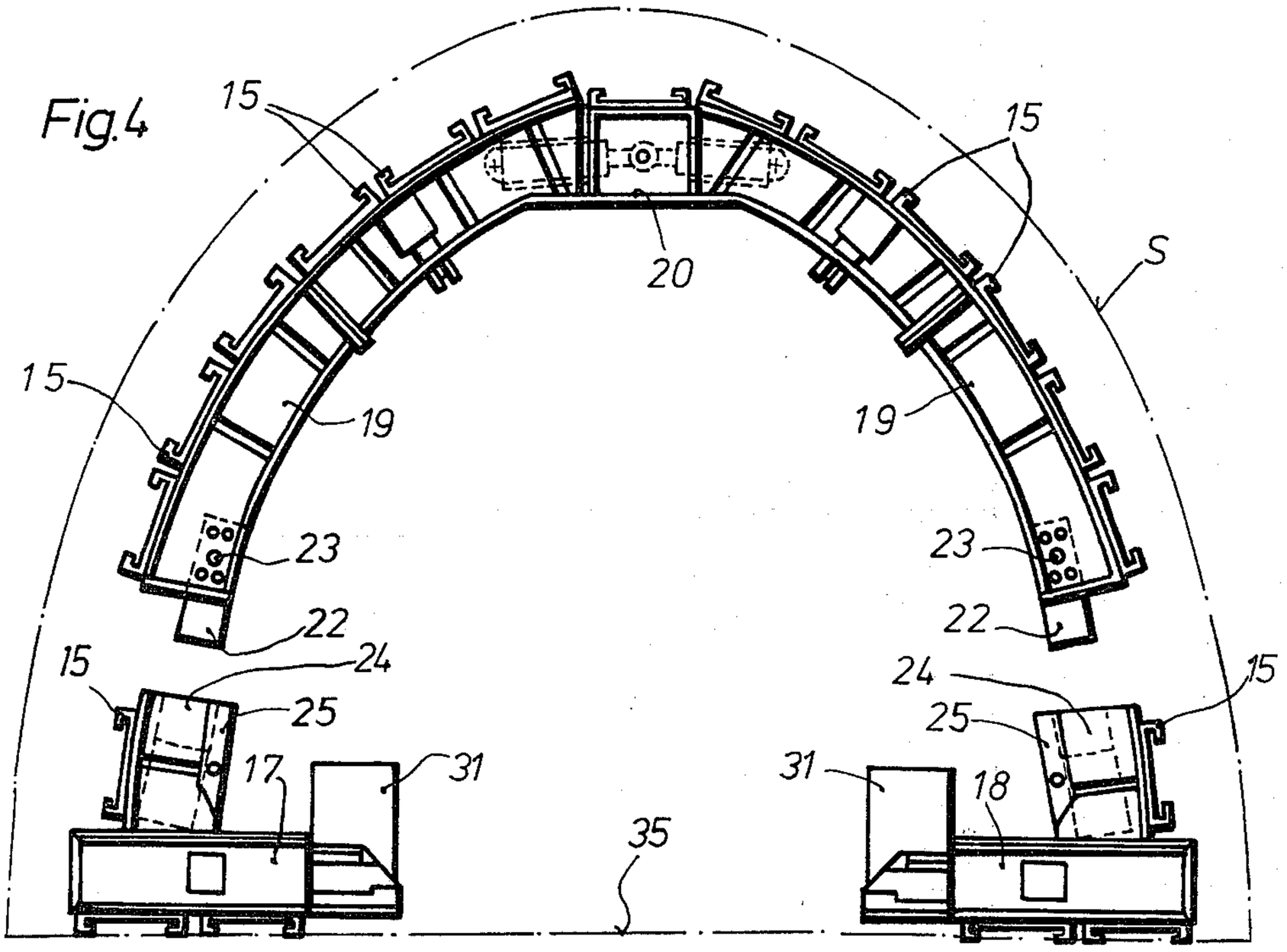
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Fig. 5

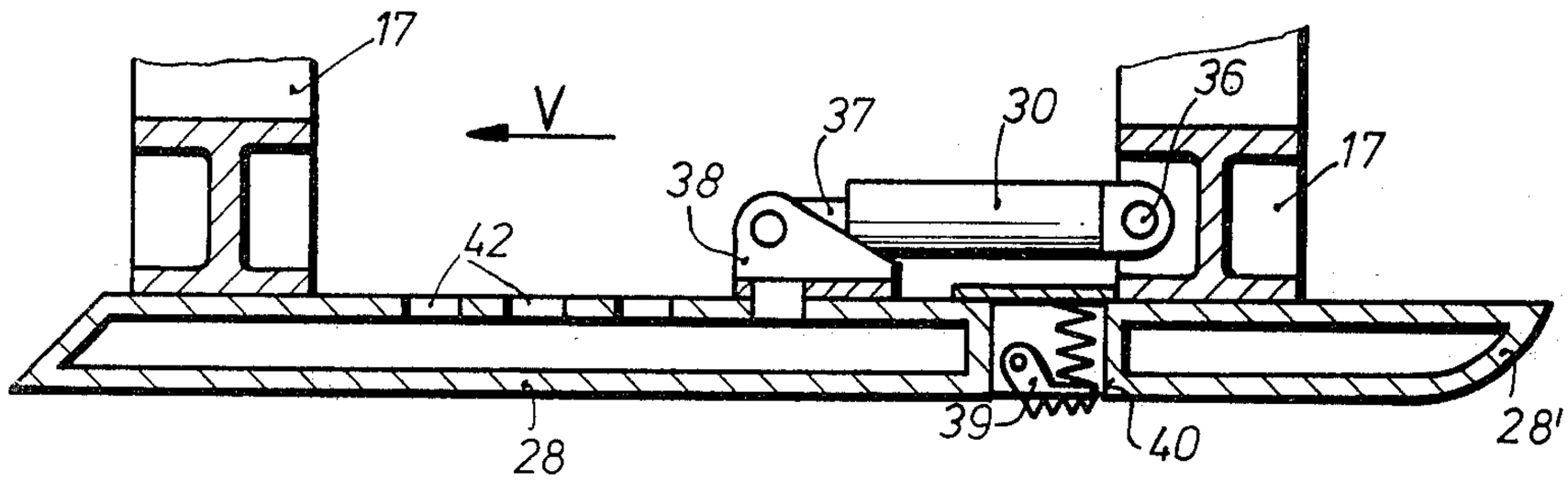


Fig. 6

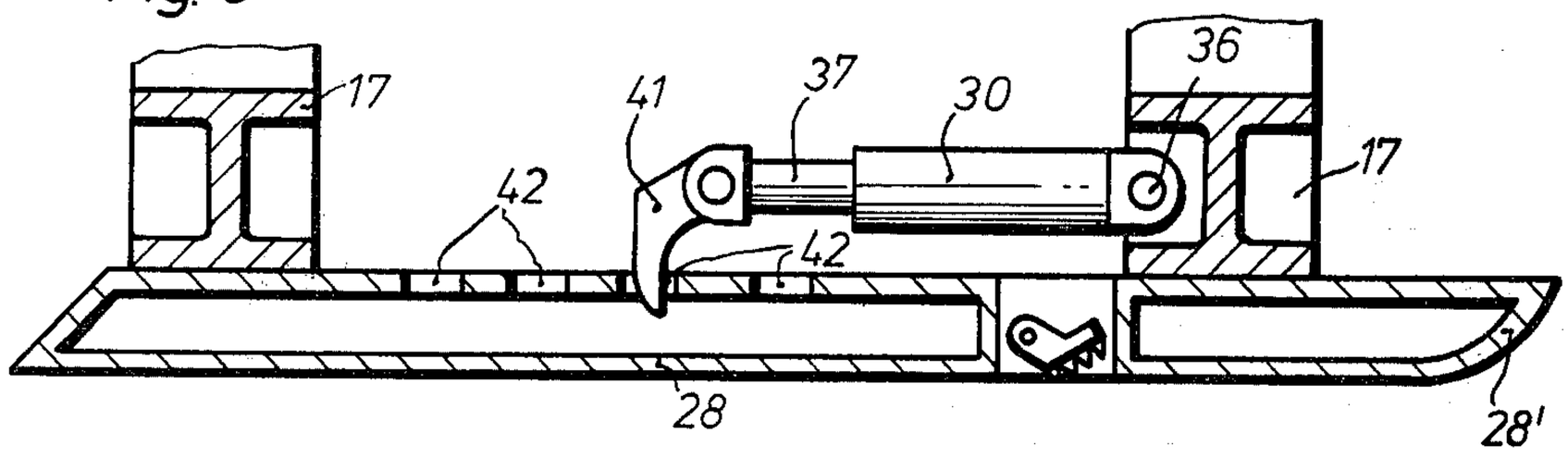
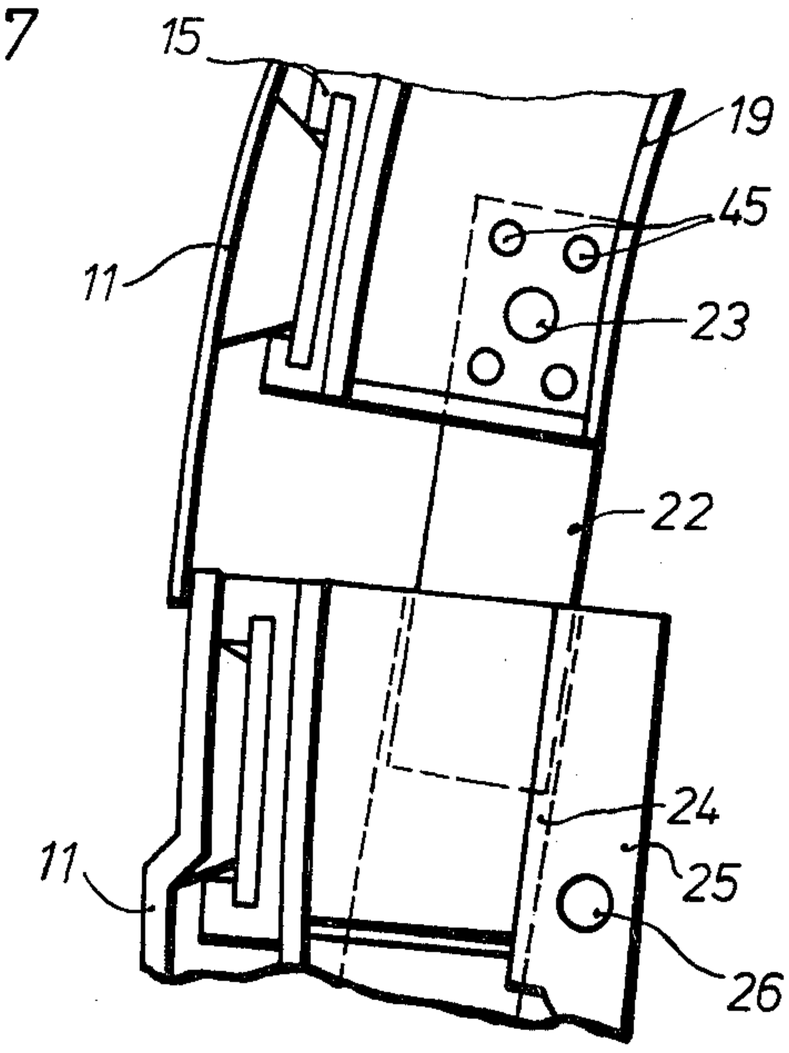


Fig. 7



TUNNEL DRIVE SHIELD

BACKGROUND OF THE INVENTION

This invention relates to a drive shield for use in forming underground tunnels, mine galleries or other elongate underground excavations, and the terms "tunnel" or "tunnelling" should be construed throughout this specification accordingly. The invention is particularly useful for driving the galleries (or roads) of underground mine workings.

A tunnel drive shield is known having a plurality of elongate drive members (or knives) carried by a support frame. The knives are positioned in a parallel side-by-side relationship to define a wall-contacting shell. The knives can be advanced, individually or in groups, relative to the support frame by means of hydraulic rams. The support frame of this shield is constituted by two components which are pivotably interconnected at the roof and carried by hydraulic props. The frame components are also connected together at the floor by means of a beam whose length can be varied by means of hydraulic rams. (See British Patent Specification No. 1463194).

Another known tunnel drive shield of this general type has a support frame having a pair of foot segments engageable with the tunnel floor, and a plurality of main segments which can be braced outwardly, by means of hydraulic rams, towards the tunnel walls. The main segments are connected to their foot segments by means of telescopic guides, and the hydraulic bracing rams are arranged to apply their bracing forces roughly in the axial direction of the telescopic guides. The foot segments of the support frame are provided with floor skids, on which the entire shield is supported. (See U.S. Pat. No. 4,173,421).

The disadvantage of these known tunnel drive shields is that it is very difficult to assemble and dismantle them in the constricted space of underground tunnels or galleries. In practice, the assembly and dismantling of such shields necessitates special underground work chambers whose cross-sections are considerably greater than that of the tunnel being formed. The provision of these large work chambers results in a considerable amount of extra work, and involves additional high costs. Moreover, it leads to excessively long assembly and dismantling times.

The aim of the invention is to provide a tunnel drive shield which can be assembled and dismantled within the cross-section of the tunnel being driven.

SUMMARY OF THE INVENTION

The present invention provides a tunnel drive shield having an arcuate support frame constituted by a pair of foot segments and a plurality of main segments supported by the foot segments, the foot segments being engageable with the tunnel floor, and the main segments being braceable outwardly towards the tunnel walls, each foot segment being provided with at least one floor skid displaceably mounted on the base thereof, wherein each foot segment is provided with at least one vertically-movable support foot, the support feet being movable into contact with the tunnel floor to relieve, at least partially, the load on the floor skids.

Advantageously, the main segments of the support frame carry a plurality of elongate members which are arranged in parallel side-by-side relationship, the elongate members being engageable with the tunnel walls

and being movable relative to the support frame in the direction of tunnel advance. Preferably, each elongate member is provided with a hydraulic advance ram for advancing that elongate member relative to the support frame; and each elongate member slidably engages a respective guide extending parallel to the longitudinal axis of the shield, whereby the elongate members are removable from the support frame by movement in the longitudinal direction. Also, each floor skid may slidably engage a respective guide extending longitudinally along the base of the corresponding food segment, whereby the floor skids are removable from the foot segments by movement in the longitudinal direction. Thus, the elongate members and the floor skids can be removed from the shield in the direction of its tail.

Advantageously, each foot segment is provided with two floor skids, and each foot segment is provided with two longitudinally spaced support feet. The support feet may be movable vertically by means of hydraulic lifting rams, and each support foot may be detachably secured to the respective foot segment.

Preferably, the main segments comprise two wall segments and a rigid segment, each of the wall segments being connected to a respective one of the foot segments, and the two wall segments being joined together, at the top, by the ridge segment. Conveniently, each wall segment is connected to its foot segment by telescopic guide means, and the top of each wall segment is connected to the ridge segment by telescopic guide means. Advantageously, the telescopic guide means at the base of each wall segment is constituted by a first telescopic guide situated adjacent to each end thereof, and the telescopic guide means at the top of each wall segment is constituted by a second telescopic guide situated adjacent to each end thereof. Preferably, each first telescopic guide is constituted by a tongue-like member attached to the respective wall segment, and by a grooved guide member attached to the corresponding foot segment, each tongue-like member being a telescopic fit within its grooved guide member. Advantageously, each first telescopic guide is such that its tongue-like member can be completely removed from its grooved guide member when the support frame is braced outwardly, and the elongate members and the floor skids have been removed. Similarly, each second telescopic guide may be constituted by a tongue-like member attached to the ridge segment, and by a grooved guide member attached to the respective wall segment, each tongue-like member being a telescopic fit within its grooved guide member.

During dismantling, the shield can, in some cases, be raised to such an extent, with the aid of the support feet, that the floor skids are completely relieved of load, and can be removed. The shield can then be set on the tunnel floor by raising the support feet so that the shield rests on its foot segments. As this happens, sufficient free space is created between the tunnel walls and the elongate members to enable the latter to be removed. The support frame, thus stripped of its floor skids and its elongate members, is then of sufficiently small cross-section to be dismantled within the tunnel cross-section.

Advantageously, the shield further comprises hydraulic rams for bracing the main segments of the support frame outwardly towards the tunnel walls. Preferably, at least one of said hydraulic bracing rams is associated with, and acts generally in the direction of, each of the telescopic guides. In this case, the hydraulic bracing

rams can be used to assemble and dismantle the segments of the support frame.

The tongue-like member of each first telescopic guide may be pivotally attached to its wall segment. This enables the parts of the first telescopic guides to slide easily without undue force. Advantageously, the tongue-like member of each first telescopic guide is provided with detachable means for securing that tongue-like member rigidly to its wall segment.

The tunnel drive shield of the invention can also be dismantled in a tunnel whose cross-section is less than its desired (nominal) cross-section. This reduction in cross-section occurs in cases where the pressure of the surrounding earth and rock is sufficiently great. In such cases, the support frame of the shield is contracted to an extent sufficient to relieve the pressure on the shield from the surrounding earth and rock. The shield can then be dismantled. Advantageously, however, the dismantling process is facilitated if the tongue-like members of the first telescopic guides are detachably secured to their wall segments. This enables the wall segments to be separated from the foot segments without having to re-brace the wall segments outwardly. In such cases, it is also possible to withdraw the floor skids when loaded. This can be done using the hydraulic advance rams provided for advancing the floor skids relative to their foot segments. In order to assist with this skid removal step, each floor skid may be provided with a plurality of longitudinally-spaced engagement points for its associated hydraulic advance ram, whereby said ram can be used to displace that floor skid in the rearward longitudinal direction relative to its foot segment. This enables the skids to be forced out to the rear of the shield in incremental movements.

Advantageously, each elongate member is provided with openings through which holes can be drilled in the tunnel walls from the inside of the shield.

Preferably, each wall segment is constituted by a plurality of detachably connected segment parts.

A tunnel drive shield constructed in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. **1** is an end elevation of the tunnel drive shield;

FIG. **2** is a longitudinal section through the shield of FIG. **1**;

FIGS. **3** & **4** are end elevations of the shield of FIG. **1**, and show different stages of the shield dismantling process;

FIGS. **5** & **6** are longitudinal sections through a floor skid of the shield of FIG. **1**, and show different operational positions of the floor skid; and

FIG. **7** is an enlarged view of part of the tunnel drive shield.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring to the drawings, FIG. **1** shows a tunnel drive shield of arcuate cross-section. The shield has a support frame **10** which carries a plurality of elongate members (knives) **11** and **11'** having cutting edges **12** at their front ends. Each of the knives **11, 11'** is provided with a tail extension **13**; the tail extensions being articulated to their knives, and forming a hood. This hood affords protection for erecting a support **14** of a permanent tunnel lining.

Each of the knives **11,11'** is displaceably guided, for movement in the direction V of tunnel advance, in a respective T-shaped, longitudinally-extending, guide groove **15** formed in the support frame **10**. Each knife **11,11'** is provided with a double-acting hydraulic advance ram **16** (only one of which is shown—see FIG. **2**) which is pivotally attached to that knife and to the support frame. The knives **11,11'** are advanced (either singly or in groups) in the direction V by extending the rams **16**, the support frame **10** providing an abutment for the advance movement of the knives. Once all the knives **11,11'** have been advanced, the support frame **10** can be advanced, in a follow-up step, by retracting all the rams **16** simultaneously, friction between the knives and the surrounding tunnel walls providing an abutment for the frame advance.

The support frame **10** is formed as a multipart, expansible frame. It has two foot segments **17** and **18** which support wall segments **19** and a ridge segment **20**. The two foot segments **17** and **18** are of a similar construction, and the ridge segment **20** interconnects the two wall segments **19** at the tops thereof. The knives **11** are displaceably mounted on the wall segments **19**, whereas the knife **11'** (which is somewhat wider than the knives **11**) is displaceably mounted on the ridge segment **20**. The knife **11'** overlies the longitudinal edges of the two adjacent knives **11**, so that a closed covering is provided at the top of the shield.

The wall segments **19** are curvilinear, are symmetrically disposed about the axis of the shield, and are of hollow box-like construction. Each wall segment **19** is of two-part construction, the two parts being bolted together, at **21**.

Each of the wall segments **19** is pivotally mounted to its foot segment **17** or **18** respectively by means of two telescopic guides arranged at the two ends of the shield. As shown best in FIG. **7**, each of the telescopic guides associated with the foot segment **17** is constituted by a tongue-like member **22** which telescopically engage within a groove **24** formed in a guide member **25**. The tongue-like members **22** are pivotally connected, by means of pivot pins **23**, to the lower end of the wall segment **19**; and the guide members **25** are pivotally mounted, by means of pivot pins **26**, on the foot segment **17**. The telescopic guides associated with the foot segment **18** are identical to those associated with the foot segment **17**.

A respective pair of hydraulic rams **27** is associated with each of the telescopic guides, the rams of each pair sandwiching their respective telescopic guide. Each ram **27** is pivotally mounted between its associated wall and foot segments **19,17** or **19,18**. Thus expansion of the rams **27** causes the wall segments **19** to be raised relative to the foot segments **17** and **18**, this movement being guided by the telescopic guides.

Similarly, the ridge segment **20** is coupled to the tops of the wall segments **19** by means of telescopic guides at each end thereof. Each of these telescopic guides has a tongue-like member **22'** (see FIG. **1**) attached to the side of the ridge segment **20**, the tongue-like member **22'** being telescopically engageable within guide members (not shown) at the tops of the wall segment **19**. Here again, a pair of hydraulic rams **27'** is associated with each of the telescopic guides. Each ram **27'** is pivotally mounted between the ridge segment **20** and one of the wall segments **19**. The rams **27'** are used to expand the wall segment laterally towards the wall of the tunnel.

Each of the foot segments **17** and **18** is provided with a pair of floor skids **28**. Each of the floor skids **28** has a top portion shaped to engage within a respective T-shaped groove **29** formed in the underside of the associ-

ated foot segment **17** or **18**. The grooves **29** extend longitudinally, and constitute guides along which the floor skids **28** are slidable. Each floor skid **28** is provided with a double-acting hydraulic ram **30**, which is pivotally mounted between that floor skid and the associated foot segment **17** or **18**. The rams **30** are used to move the floor skids **28**, in the direction V, relative to the rest of the shield. The support frame **10** can then be moved forward, in a follow-up movement, the floor skids **28** forming a slide bearing for the foot segments **17** and **18** during this movement.

Each foot segment **17,18** is provided with a pair of longitudinally-spaced support feet **31** and **32** (see FIG. **2**). As shown in FIGS. **1,3** and **4**, the feet **31** (and **32**) are inwardly offset in relation to the floor skids **28**. Each of the support feet **31,32** is provided with a base plate **33** which is vertically movable towards (and away from) the tunnel floor **35** by means of a respective hydraulic ram **34**. In their uppermost (fully retracted) positions, the base plates **33** have a ground clearance X (see FIG. **1**), this clearance being at least equal to (and preferably slightly greater than) the distance Y between the tunnel floor **35** and the bases of the T-shaped grooves **29**. The support feet **31** and **32** may be solidly or detachably connected to their foot segment, **17** and **18**.

As shown in FIG. **1**, the shield is outwardly braced, by means of the rams **27** and **27'**, to conform with the desired cross-section of the tunnel. During normal use of the shield, the support feet **31** and **32** are fully retracted, so that the shield rests on the tunnel floor **35** on its skids **28**. In order to dismantle the shield once the tunnel has been completed, all the rams **27** and **27'** are retracted so that the knives **11** and **11'** are withdrawn inwardly away from the tunnel walls S (see FIG. **3**). The support feet **31** and **32** are then forced down, by the rams **34**, into contact with the tunnel floor **35**. This lifts the floor skids **28** away from the tunnel floor **35**, so that the entire weight of the shield is borne by the support feet. The floor skids **28** can then be withdrawn from the T-shaped grooves **29** towards the tail of the shield. Next, the support feet **31** and **32** are retracted so that the shield is lowered until it is supported on the tunnel floor **35** by means of its foot segments **17** and **18** (see FIG. **4**). During this lowering operation, a free space is created between the tunnel walls S and the outer surface of the shield. This free space has a greater radial dimension than that through which the shield segments **19** and **20** can be braced by the rams **27** and **27'**. The knives **11** and **11'** can then be withdrawn from their T-shaped grooves towards the tail of the shield.

In order to dismantle the support frame **10**, the rams **27** are then fully extended. As this happens, the tongue-like members **22** move out of the grooves **24** of their guide members **25** (see FIG. **4**). The upper segments **19** and **20** of the support frame **10** can then be held in this position (using, for example, a block-and-tackle), whilst the rams **27** are removed. The foot segments **17** and **18**, which are now exposed, can then be removed either in one piece or part-by-part. It is then possible to lower the upper segments **19** and **20** on to the tunnel floor **35**, and to separate the segments **19** from the segment **20**. The segments **19** and **20** can then be transported to the next location at which the shield is to be used.

Obviously, the shield is assembled in the reverse order to that described above, this assembly process also being possible within the confines of the tunnel to be formed.

The shield can also be assembled, and dismantled, in a tunnel whose cross-section is smaller than the desired (or nominal) cross-section, this reduction in cross-section occurring because of the pressure of the surrounding earth and rock. When such pressure occurs, the shield contracts slightly as its rams **27** and **27'** retract in taking up the pressure. If the rams **27** and **27'** are fully retracted by such pressure, the shield is dismantled in the following manner. Firstly, the support feet **31** and **32** are extended until their base plates **33** bear against the tunnel floor **35**. Then, the floor skids **28** (which are still under load) are withdrawn from their T-shaped grooves **29** towards the shield tail, this being achieved with the aid of suitable auxiliary equipment. After removal of the skids **28**, the support feet **31** and **32** are retracted sufficiently far to lower the shield so that the foot segments **17** and **18** rest on the tunnel floor **35**. The telescopic connection between the foot segments **17** and **18** and the wall segments **19** is then released by removing the pivot pins **23** of the tongue-like members **22**. The members **22** can then be displaced upwards within the wall segments **19** until they move out of engagement with the grooves **24** of the guide members **25**. This releases the foot segments **17** and **18**, which can then be carried away. The upper segments **19** and **20** can then be dismantled in the manner described above.

Particularly when the floor skids **28** have to be removed whilst under load, it is advisable to make use of the rams **30**. As shown in FIG. **5**, each ram **30** is pivotally connected to its foot segment **17** (or **18**) and to its floor skid **28** by means of pivot joints **36**. The piston rods **37** of the rams **30** are detachably connected to the associated floor skids **28** by means of respective links **38**. The rear end **28'** of each floor skid **28** is curved upwardly, and each floor skid is provided with a pawl **39** housed within a downwardly-open recess formed in the base of that floor skid forwardly of the curved end portion. The pawl **39** of each floor skid is biassed down into contact with the tunnel floor **35** by means of a spring **40**. The pawls **39** thus act to prevent the floor skids **28** from moving in a direction opposite to the direction V of tunnel advance. In order to remove a given floor skid **28**, its spring **40** is removed (or rendered ineffective), and the link **38** is released from the skid and replaced by a hook-shaped coupling member **41** (see FIG. **6**). The coupling member **41** is fixed to the piston rod **37** of the associated ram **30**, so that its free end can engage in one of a series of longitudinally-spaced holes **42** formed in the top surface of the floor skid **28** (which is of hollow box-girder formation). The coupling member **41** is engaged with one of the holes **42** when the ram **30** is fully extended. The ram **30** is then fully retracted so that the floor skid **28** is moved towards the shield tail by a distance equal to the working stroke of the ram **30**. The coupling member **41** is then disengaged from the hole **42**, the ram **30** is fully extended, the coupling member is engaged with another hole **42**, and the ram **30** is fully retracted again. In this way, the floor skids **28** can be removed from the shield, using their rams **30**, in a number of steps. It will be understood that, during this process, the support feet **31** and **32** are extended to contact the tunnel floor **35**.

Retraction and removal of the knives **11** and **11'** could be effected using their rams **16**. It is also possible, however, to withdraw the knives **11** and **11'** using auxiliary equipment such as cables or chains.

Preferably, the knives **11** and **11'** (and their tail extensions **13**) are apertured, so that holes **43** (see FIG. **1**) can

be drilled in the surrounding earth from the interior of the shield. Grout can then be injected into the holes **43** so as to strengthen the earth to prevent it breaking up when the shield is advanced.

As best seen in FIG. **2**, the floor skids **28** are shorter than the knives **11,11'**, and cutters **44** are provided in front of the floor skids. The cutters **44** are bolted to the floor skids **28** and serve to cut the working face of the tunnel in the regions below the knives **11**. The cutters **44** can be removed from the support frame **10** when the shield is being dismantled.

As shown in FIG. **7**, the tongue-like members **22** can be rigidly fixed to their respective wall segments **19** by means of bolts **45**. These bolts are removed when it is required to move the tongue-like members **22** within their guide grooves **24** without unnecessary force.

Obviously, a number of modifications could be made to the shield described above. In particular, the hook-shaped coupling members **41** could be replaced by spring-biassed pins attached to the links **38**, the pins latching into the apertures **42** in the floor skids **28**. Moreover, the foot segments **17** and **18** could be connected by a support structure for a tunnelling machine mounted inside the shield.

I claim:

1. A tunnel drive shield having an arcuate support frame including a pair of foot segments and a plurality of main segments supported by the foot segments, the foot segments being engageable with the tunnel floor, and the main segments being braceable outwardly towards the tunnel walls, each foot segment being provided with at least one floor skid displaceably mounted on the base thereof, wherein each foot segment is provided with at least one vertical-movable support foot, the support feet being movable into contact with the tunnel floor to relieve, at least partially, the load on the floor skids.

2. A tunnel drive shield according to claim **1**, wherein the main segments of the support frame carry a plurality of elongate members which are arranged in parallel side-by-side relationship, the elongate members being engageable with the tunnel walls and being movable relative to the support frame in the direction of tunnel advance.

3. A tunnel drive shield according to claim **2**, wherein each elongate member is provided with a hydraulic advance ram for advancing that elongate member relative to the support frame.

4. A tunnel drive shield according to claim **3**, wherein each elongate member slidably engages a respective guide extending parallel to the longitudinal axis of the shield, whereby the elongate members are removable from the support frame by movement in the longitudinal direction.

5. A tunnel drive shield according to claim **1**, wherein each floor skid slidably engages a respective guide extending longitudinally along the base of the corresponding foot segment, whereby the floor skids are removable from the foot segments by movement in the longitudinal direction.

6. A tunnel drive shield according to claim **1**, wherein each foot segment is provided with two floor skids.

7. A tunnel drive shield according to claim **1**, wherein each foot segment is provided with two longitudinally spaced support feet.

8. A tunnel drive shield according to claim **1**, wherein the support feet are movable vertically by means of hydraulic lifting rams.

9. A tunnel drive shield according to claim **1**, wherein each support foot is detachably secured to the respective foot segment.

10. A tunnel drive shield according to claim **1**, wherein the main segments comprise two wall segments and a ridge segment, each of the wall segments being connected to a respective one of the foot segments, and the two wall segments being joined together, at the top, by the ridge segment.

11. A tunnel drive shield according to claim **10**, wherein the base of each wall segment is connected to its foot segment by telescopic guide means, and the top of each wall segment is connected to the ridge segment by telescopic guide means.

12. A tunnel drive shield according to claim **11**, wherein the telescopic guide means at the base of each wall segment includes a first telescopic guide situated adjacent to each end thereof, and the telescopic guide means at the top of each wall segment includes a second telescopic guide situated adjacent to each end thereof.

13. A tunnel drive shield according to claim **12**, wherein each first telescopic guide includes a tongue-like member attached to the respective wall segment, and a grooved guide member attached to the corresponding foot segment, each tongue-like member being a telescopic fit within its grooved guide member.

14. A tunnel drive shield according to claim **13**, wherein the tongue-like member of each first telescopic guide is completely removable from its grooved guide member when the support frame is braced outwardly, and the elongate members and the floor skids have been removed.

15. A tunnel drive shield according to claim **12**, wherein each second telescopic guide includes a tongue-like member attached to the ridge segment, and a grooved guide member attached to the respective wall segment, each tongue-like member being a telescopic fit within its grooved guide member.

16. A tunnel drive shield according to claim **12**, further comprising hydraulic rams for bracing the main segments of the support frame outwardly towards the tunnel walls.

17. A tunnel drive shield according to claim **16**, wherein at least one of said hydraulic bracing rams is associated with, and acts generally in the direction of, each of the telescopic guides.

18. A tunnel drive shield according to claim **13**, wherein the tongue-like member of each first telescopic guide is pivotally attached to its wall segment.

19. A tunnel drive shield according to claim **18**, wherein the tongue-like member of each first telescopic guide is provided with detachable means for securing that tongue-like member rigidly to its wall segment.

20. A tunnel drive shield according to claim **13**, wherein the tongue-like members of the first telescopic guides are detachably secured to their wall segments.

21. A tunnel drive shield according to claim **2**, wherein each elongate member is provided with openings through which holes can be drilled in the tunnel walls from the inside of the shield.

22. A tunnel drive shield according to claim **1**, further comprising cutters disposed forwardly of the floor skids, the cutters being detachably secured to the support frame.

23. A tunnel drive shield according to claim **10**, wherein each wall segment includes a plurality of detachably connected segment parts.

24. A tunnel drive shield according to claim 1, wherein each floor skid is provided with a hydraulic advance ram for advancing that floor skid relative to its foot segment.

25. A tunnel drive shield according to claim 24, wherein each floor skid is provided with a plurality of longitudinally-spaced engagement points for its associated hydraulic advance ram, whereby said ram can be used to displace that floor skid in the rearward longitudinal direction relative to its foot segment.

26. A tunnel drive shield according to claim 1, wherein the base of each floor skid is curved upwardly at its rearward end.

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